polishing the same until the insulation film is exposed to form the metal interconnection of the interconnection material, barrier layer and the adhesion layer buried in the opening.

REMARKS

The Office Action dated June 6, 2002 has been received and carefully noted. The above amendments to the claims, and the following remarks, are submitted as a full and complete response thereto. By this Amendment, claims 1, 2, 5, 6, 7, 14, 15, 17 and 22 are amended. No new matter is added. Consideration of claims 1-26 is respectfully requested.

The Office Action rejected claims 1, 2, 6, 7, 13-15, 17, 19, 20, 22, and 26 under 35 U.S.C. §103(a) as being unpatentable over Dubin (U.S. Patent No. 6,249,055) in view of Kim et al (U.S. Patent No. 4, 751,349). The Office Action takes the position that the combination of Dubin and Kim teach or suggest all the features of the claimed invention. Applicant respectfully submits that the present invention recites subject mater that is neither taught nor suggested by applied prior art. Thus, in view of the above amendments and the following remarks, Applicant requests favorable consideration of claims 1, 2, 6, 7, 13-15, 17, 19, 20, 22, and 26.

Claim 1 is directed to a metal interconnection buried in an insulation film. The invention comprises an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material. The invention also comprises an adhesion layer that of Zr or ZrN formed between the barrier layer and the interconnection material. The adhesion layer is for improving the adhesion between the barrier layer and the interconnection material.

Claim 2 recites a metal interconnection buried in an insulation film comprising an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material, and an adhesion layer containing zirconium formed between the insulation film and the barrier layer. The adhesion layer is for improving an adhesion between the insulation film and the barrier layer.

Claim 6 is directed to a semiconductor device that comprises a base substrate

having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate, and an insulation film formed on the base substrate. The insulation film has an opening. The device further comprises a metal interconnection formed buried in the opening which includes an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material, and an adhesion layer of Zr or ZrN formed between the barrier layer and the interconnection material. The adhesion layer is for improving the adhesion between the barrier layer and the interconnection material.

Claim 7 is directed to a semiconductor device comprising a base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate, an insulation film formed on the base substrate, the insulation film having an opening, and a metal interconnection formed buried in the opening. The device also comprises a metal interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material, and an adhesion layer containing zirconium formed between the insulation film and the barrier layer. The adhesion layer is for improving the adhesion between the insulation film and the barrier layer.

Claim 14 recites a method for forming a metal interconnection buried in an insulation film. The steps of the method include forming a barrier layer on the insulation film, forming an adhesion of Zr or ZrN directly on the barrier layer, and forming an interconnection material containing copper as a main component on the adhesion layer.

Claim 17 is directed to a method for fabricating a semiconductor device comprising the steps of forming an insulation film on the base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate, selectively removing the insulation film to form an opening in the insulation film, and forming a barrier layer on the insulation film and a region where the opening is formed. The method also includes the steps of forming a first adhesion layer of Zr or ZrN directly on the barrier layer, forming an interconnection material containing copper as a main component on the first adhesion layer so as to fill the opening, and removing the interconnection material. The first adhesion layer and the barrier layer by polishing the same until the insulation film is exposed to form the metal interconnection of the interconnection material, the first

adhesion layer and the barrier layer buried in the opening.

Claim 22 is directed to a method for fabricating a semiconductor device comprising the steps of forming an insulation film on the base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate, selectively removing the insulation film to form an opening in the insulation film and forming an adhesion layer containing zirconium on the insulation film and a region where the opening is formed. The method also includes the steps of forming a barrier layer directly on the adhesion layer, forming an interconnection material containing copper as a main component as a main component on the barrier layer so as to fill the opening, and removing the interconnection material, the barrier layer and the adhesion layer by interconnection material. The adhesion layer is for improving the adhesion between the barrier layer and the interconnection material.

The benefits provided by the claimed invention, as recited in claims 1, 2, 5, 6, 7, 14, 15, 17, and 22, is a result of the recited feature of a adhesion layer of Zr or ZrN formed between the barrier layer and the interconnection layer, wherein the adhesion layer improves the adhesion between the barrier layer and the interconnection material. The applied prior art as taught neither teaches nor suggests the benefits provided by an adhesion layer, as claimed in the present invention. More specifically, the applied prior art neither teaches nor suggests an adhesion layer for improving adhesion between the barrier layer and the interconnection layer.

Dubin is directed to a method of electroplating or electroless plating of Cu or Cu alloy metallization having high corrosion resistance without any substantial Cu diffusion. More specifically, Dubin discloses a metal interconnection including a Cu interconnect layer 54, Cu seed layer 56, TaN barrier layer 52, Al barrier layer 55 and insulating film structure 10. The Office Action notes that the seed layer 56 corresponds to the adhesion layer of the present invention.

It is respectfully submitted that the seed layer 56 of Dubin is not the same as the adhesion layer of the present invention. The adhesion layer of the present invention is to improve the adhesion between the barrier layer and the interconnection layer. In contrast, the seed layer 56 of Dubin is formed between the Cu metallization 54 and the Al or Mg alloy layer 53. More specifically, the seed layer 56 is not in contact with the barrier layer

52. As a result, the seed layer 56 does not improve the adhesion between the Cu metallization 54 and barrier layer 52, rather the seed layer 56 improves the adhesion between the Cu metallization 54 and the Al or Mg alloy layer 53. Thus, Dubin neither teaches nor suggest the adhesion between the Cu metallization 54 and the barrier layer 52. Also, the seed layer 56 is for growing the Cu metallization, so that copper is contained in the seed layer 56. In other words, Dubin discloses that the seed layer 56 may be made of an alloy of Cu and Mag, Al, Zn, Zr, Sn, Ni, Pd, Ag, or Au. Thus, Dubin neither teaches nor suggest the Zr adhesion layer and ZrN adhesion layer. Therefore, it is respectfully submitted that Dubin neither teaches nor suggests the features of the claimed invention.

Kim discloses Zirconium adhesion material in a multi-layer metallic structure. More specifically, the Office Action utilizes Zr layer 44 to teach or suggest the adhesion layer of the present invention. However, Applicant respectfully submits that the Zr layer 44 of Kim is not the same as the adhesion layer as claimed in the present invention.

Specifically, the adhesion layer of the claimed invention is an adhesion layer of Zr or ZrN formed between the barrier layer and the interconnection material, the adhesion layer being for improving the adhesion between the barrier layer and the interconnection material. Thus, the adhesion layer of the present invention is to improve the adhesion between the barrier layer and the interconnection layer, so that the adhesion layer is formed between the barrier layer and the interconnection material. In contrast, the Zr layer of Kim is formed between the Cu layer 46 and the insulating substrate 40. Thus, Kim neither teaches not suggests the barrier layer formed between the Cu layer 46 and the substrate 40. As a result, the Zr layer 44 is not for improving the adhesion between the Cu layer and the barrier layer but for improving the adhesion between the Cu layer 46 and the substrate 40. Accordingly, Kim does not teach or suggest the feature of an adhesion layer utilized for improving the adhesion between the barrier layer and the interconnection material. Furthermore, the teachings of Kim does not cure the deficiencies of Dubin. Therefore, it is submitted that the combination of Dubin and Kim neither teach nor suggest all the features of the claimed invention. Thus, Applicant requests the withdrawal of the rejection of claims 1, 2, 6, 7, 14, 15 and 17 under 35 U.S.C. 103(a).

Claims 3, 4, 8-12, 16, 18, 21, and 23-25 were rejected under 35 U.S.C 103(a) as being unpatentable over Dubin (U.S. Patent 6,249,055) in view of Kim et al (U.S. Patent

4,751,349) and in further view of Venkatraman (U.S. Patent 5,677,244). The Office Action states that the combination of Dubin and Kim teach all the elements presented in the rejected claims except for a copper interconnection structure where islands are grown. The Office Action utilizes Venkatraman to teach this claimed feature. Applicant respectfully submits that the combination of the applied art neither teaches nor suggests all the claimed features of the present invention.

Although Venkatraman discloses a copper interconnection structure where islands are grown, the teachings of Venkatraman are not utilized in Cu interconnection technology. Specifically, the discontinuous Cu film or islands is not used to improve the adhesion between the barrier layer 13 and the Al conductive layer 14, but rather for doping Cu into the Al conductive layer 14. Thus, when the continuous Cu film is formed between the barrier layer 13 and the Al conductive layer 14, the adhesion between the barrier layer 13 and the Al conductive layer 14 is degraded. As a result, the Cu film as disclosed in Venkatraman is discontinuously formed on the barrier layer 13. It should be noted when the discontinuous Cu film is not formed on the barrier layer 13 and the Al conductive layer 14, the adhesion is improved. In contrast, in the claimed invention the islands of Cu-Zr improves the adhesion between the adhesion layer and the barrier layer. Thus, the islands of Cu-Zr alloy of the present invention are neither taught nor suggested by the applied prior art. Furthermore, there is no motivation to use the teachings of Venkatraman with that of Dubin and Kim to teach or suggest the claimed features of the present invention. Therefore, Applicant requests the withdrawal of the rejection of claims 3, 4, 8-12, 16, 18, 21, and 23-25.

Claim 5 was rejected under 35 U.S.C 103(a) as being unpatentable over Dubin in view of Kim et al and Nogami et al. (U.S. Patent No. 6,284,656). Applicant respectfully submits that the combination of Dubin, Kim and Nogami neither teach nor suggest all the elements recited in claim 5.

Claim 5 is directed to a metal interconnection buried in an insulation film comprising an interconnection material containing copper as a main component, a barrier layer formed between the insulation film and the interconnection material, and an adhesion layer containing a metal material having a solid solubility limit of not more than 20 wt% in copper and a resistivity increase of not more than 19.8% when solved in copper formed on the

barrier layer and not containing copper. The adhesion layer is for improving the adhesion between the barrier layer and the interconnection material.

Nogami is directed to a copper interconnect for enhancing the electro-migration resistance. The Office Action takes the position that the seed layer disclosed in Nogami is the same as the adhesion layer of the present invention. Applicant submit that the adhesion layer as claimed in the present invention is not the same as the seed layer of Nogami. Specifically, the seed layer of Nogami is for growing the Cu layer, so that copper is contained in the seed layer. Further, Nogami discloses that the seed layer may be made of an alloy of Cu and Mg, Al, Zn, Zr, Sn, Ni, Pd, Ag, or Au. However, the adhesion layer of the present invention is not the seed layer. As a result, the adhesion layer of the claimed invention does not contain copper. Also, Nogami neither teaches nor suggests the adhesion layer containing a metal material having a solid solubility limit of not more than 20% weight in copper and a resistivity increase of not more than 19.8% when dissolved in copper formed on the barrier layer and not containing copper. Accordingly, Nogami does not cure the deficiencies of Dubin and Kim. Additionally, it is submitted that it would not have been obvious to one of the ordinary skill to combine the teaching of Dubin, Kim and Nogami to teach the features of the claimed invention. In other words, there is no motivation to combine the prior art teach or suggest the claimed invention. Therefore, Applicant requests withdrawal of the rejection of claim 5 under 35 U.S.C. 103(a).

In view of the distinctions discussed above, withdrawal of the rejections to claims 1-25 is respectfully requested. Specifically, claims 1, 2, 5, 6, 7, 14, 15, 17, and 22 have been amended. No new matter is presented. It is respectfully submitted that claims 1-26 recite subject matter that is neither taught nor suggested by the applied prior art. Therefore, Applicant submits that the application is now in condition for allowance with claims 1-26 contained therein.

Should the Examiner believe the application is not in condition for allowance, the Examiner is invited to contact Applicant's undersigned attorney at the telephone number listed below.

In the event this paper is not considered to be timely filed, Applicant respectfully petitions for an appropriate extension of time. The Commissioner is authorized to charge payment for any additional fees which may be required with respect to this paper to Counsel's Deposit Account 01-2300.

Respectfully submitted,

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Enclosures: Marked-Up Copy of Amended Claims

MARKED-UP COPY OF CLAIMS

1. (Amended) A metal interconnection buried in an insulation film comprising:

[a barrier layer formed on the insulation film;

an adhesion layer containing zirconium formed on the barrier layer; and]

an interconnection material containing copper as a main component [formed on the barrier layer] ;

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing zirconium formed between the barrier layer and the interconnection material, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material.

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2. (Amended) A metal interconnection buried in an insulation film comprising:

[an adhesion layer containing zirconium formed on the insulation film;

a barrier layer formed on the adhesion layer; and]

an interconnection material containing copper as a main component [formed on the barrier layer];

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing zirconium formed between the insulation film and the barrier layer, the adhesion layer being for improving an adhesion between the insulation film and the barrier layer.

5. (Amended) A metal interconnection buried in an insulation film comprising:

[a barrier layer formed on the insulation film;

an adhesion layer containing a metal material having a solid solubility limit of not more than 20 wt% in copper and a resistivity increase of not more than 19.8 % when solved in copper formed on the barrier layer; and]

an interconnection material containing copper as a main component [formed on the adhesion layer];

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing a metal material having a solid solubility limit of not more than 20 wt% in copper and a resistivity increase of not more than 19.8% when solved in copper, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material.

6. (Amended) A semiconductor device comprising:

a base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate;

an insulation film formed on the base substrate, the insulation film having an opening; and

a metal interconnection formed buried in the opening including:

[a barrier layer formed on an inside wall and a bottom of the opening;

an adhesion layer containing zirconium formed on the barrier layer; and]

a metal interconnection material containing copper as a main component [formed on the adhesion layer];

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing zirconium formed between the barrier layer and the interconnection material, the adhesion layer being for improving an adhesion between the barrier layer and the interconnection material.

7. (Amended) A semiconductor device comprising:

a base substrate having a semiconductor substrate and a semiconductor element

formed on the semiconductor substrate;

an insulation film formed on the base substrate, the insulation film having an opening; and

a metal interconnection formed buried in the opening including:

[an adhesion layer containing zirconium formed on an inside wall and a bottom of the opening;

a barrier layer formed on the adhesion layer; and]

a metal interconnection material containing copper as a main component [formed on the barrier layer];

a barrier layer formed between the insulation film and the interconnection material; and

an adhesion layer containing zirconium formed between the insulation film and the barrier layer, the adhesion layer being for improving an adhesion between the insulation film and the barrier layer.

14. (Amended) A method for forming a metal interconnection buried in an insulation film, comprising the steps of:

forming a barrier layer on the insulation film;

forming an adhesion layer containing zirconium directly on the barrier layer; and

forming an interconnection material containing copper as a main component on the adhesion layer.

15. (Amended) A method for forming a metal interconnection buried in an insulation film, comprising the steps of:

forming an adhesion layer containing zirconium on the insulation film;

forming a barrier layer directly on the adhesion layer; and

forming an interconnection material containing copper as a main component on the

barrier layer.

17. (Amended) A method for fabricating a semiconductor device comprising the steps of:

forming an insulation film on the base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate;

selectively removing the insulation film to form an opening in the insulation film;

forming a barrier layer on the insulation film and a region where the opening is formed;

forming a first adhesion layer containing zirconium directly on the barrier layer;

forming an interconnection material containing copper as a main component on the first adhesion layer so as to fill the opening; and

removing the interconnection material, the first adhesion layer and the barrier layer by polishing the same until the insulation film is exposed to form the metal interconnection of the interconnection material, the first adhesion layer and the barrier layer buried in the opening.

22. (Amended) A method for fabricating a semiconductor device comprising the steps of:

forming an insulation film on the base substrate having a semiconductor substrate and a semiconductor element formed on the semiconductor substrate;

selectively removing the insulation film to form an opening in the insulation film;

forming an adhesion layer containing zirconium on the insulation film and a region where the opening is formed;

forming a barrier layer directly on the adhesion layer;

forming an interconnection material containing copper as a main component on the barrier layer so as to fill the opening; and

removing the interconnection material, the barrier layer and the adhesion layer by polishing the same until the insulation film is exposed to form the metal interconnection of the

interconnection material, barrier layer and the adhesion layer buried in the opening.